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STUDIES ON WEED CONTROL IN UPLAND RICE[1]

J. R. VELASCO, M. R. VEGA, P. A. LLENA, and S. R. OBIEN

Observations on tests of various weed control methods in upland rice production seem to warrant the following conclusions:

1. The composition of the weed vegetation changes from season to season. A weeding practice which tends to eliminate one weed species may abet directly or indirectly the multiplication of another.

2. By continuous cropping and adherence to clean culture the weed problem may be greatly minimized.

3. The most feasible and economical system of weeding makes use of (1) spud weeding at 10 to 15 days after planting, (2) spraying with 2,4-D at 10 to 15 days and, in case of frequent rains, at 20-40 days after planting in order to maintain a sterile cover, and (3) thorough spud weeding and handweeding at 45 days.

4. A lush-growing upland rice variety greatly minimizes encroachments by weeds.

The upland culture (or drained culture) of rice is not extensively adopted because of certain problems which the farmers have not been able to solve successfully. Principal among them is the weed problem. Most tropical fields are heavily seeded with all kinds of weeds. This is partly a result of the total neglect of the field after the rice crop is harvested. In addition, the favorable climate allows the growth of weeds throughout the year. This is in contrast with the natural check on weed growth and multiplication imposed by the winter season in temperate countries.

It is not unusual to see weeds coming out with the rice seedlings so that the latter is lost in the profusion of the green cover which dominates the plowed field after the first rain in May. The weeds grow so lush as to rob the crop of the nutrients intended for it and practically smother it. The farmer has to remove the weeds within a short period of time, otherwise the damage they inflict on the crop would be so great as to be irreparable.

Among the most persistent weeds in rice fields are the grasses, which, being in the same family as rice, have morphological and

[1] Central Experiment Station Contribution No. 2062. Part of Project No. 582 NARIC Grant and Project No. 22 Rice and Corn Production Fund.

physiological characteristics similar to the latter. It is therefore hard to control them selectively by modifying certain factors of the environment, or by certain chemicals. In most cases, the farmer has to pick them out by hand, or by some crude tool as the *dulus*. Sometimes the converse job of picking out the crop from the weeds is a lot easier. Even among fields with moderate weed population, weeding operations entail a great portion of the farmer's time and constitute a big item of expense.

The progress of weed infestation in the kaingin rice culture (a kind of drained culture) is an interesting illustration of how destructive the weeds could be. The first time a primitive farmer clears a woodlot and plants his rice crop, he gets a worthwhile rice yield. Most of the weeds he has to contend with are broadleaved weeds which are not very persistent. They may be cut or pulled out and laid between the hills of rice to serve as mulch and to prevent re-growth of weeds. In the meantime, the crop grows fast and occupies the whole space. It can grow fast because the soil is still fertile and has a good supply of organic matter.

During the second cropping season, the composition of the weed population shifts towards the grasses (usually cogon, *Imperate cylindrica* (L) Beauv.). This probably results from (1) the incidental favor which grasses receive from the farmer's system of weeding, and (2) the reduced organic matter and nitrogen in the soil. Grasses, being more persistent, manage to strike root after having been pulled out and laid between hills. They then come to seed and the seeds get dispersed. On the other hand the soil, through the processes of cropping, leaching and erosion, rapidly loses its organic matter. The condition favors the grasses, especially cogon.

The grass problem becomes progressively grave with the succeeding rice crops and, after the third crop, the place usually becomes unfit for cultivation. The primitive farmer is left no alternative but to abandon the place and clear another woodlot.

The writers, like many of their colleagues in Philippine agriculture, feel the need for a good method of weed control; hence, these experiments which were initiated in 1956, in the Central Experiment Station of the College of Agriculture, U.P. The principal objectives of the study were: (1) to find if herbicides can be used effectively as a substitute or a complement to mechanical weeding, and (2) to devise a feasible system of weed control in upland rice

culture adopting (if necessary) chemicals, mechanical weeders and cultural practices.

MATERIALS AND METHODS

In March or April, 1955, the Central Experiment Station was divided into lots of about one hectare each and assigned to the various departments. The Department of Agricultural Botany was assigned lot No. 11 (latter, designated as Block A, lot 4), which was used in these experiments.

In 1955 and 1956, preliminary experiments to study the effects of various herbicides on local plants were conducted on 2-by-8 meter plots. The results of these experiments will not be presented in detail but will be incidentally mentioned at pertinent points in this report. It may be sufficient to mention at this point that the results were used in narrowing down the field of choice to a few chemicals in the subsequent experiments.

In May, 1957, this lot was divided into 16 plots of 10 by 50 meters each, with buffer strips of at least one-half meter between plots. The divisions were made more or less permanent throughout the experiments. Treatments were laid out in four-by-four Latin square design. In the later experiments, the previous treatments of the plot were considered in planning the treatment for the season. Whenever pertinent, they were also used to shed light on the results of the current treatment.

In all the experiments in this study, the land was plowed with a tractor-drawn disc plow in April. The field was then harrowed twice with a disc harrow—once in the middle of May and another in late May or early June, just before seeding. The operations were designed to bury the trash and weeds and allow them to rot.

The field was seeded with a tractor-drawn grain drill at 35 centimeters between rows. Approximately 1.5 cavans of seed were drilled in one hectare.

In the care and management of the field and in harvesting the crop, standard procedures in upland rice culture were followed. A top dressing of nitrogen was given the crops at 40 to 60 days of age. Ammonium sulfate was applied at the rate of 150 kilograms per hectare. The plants in the 1958 and 1959 experiments were fertilized with potassium chloride at 200 kilograms per hectare when they were 70 to 80 days old. This was done because of the observed

favorable effects of late potassium fertilization on pot-grown rice plants.

Another study showed that water deficit during booting had a marked detrimental effect on grain yield; so, to avoid losses from drought which might occur at the period, overhead irrigation pipes were installed in the field and used when no rain fell for five successive days during booting and emergence.

Weed-control operations are described under each of the experiments. The herbicides were applied with either a knapsack sprayer with a 2-meter boom (fig. 1), a jeep-powered sprayer with a 5-meter boom (fig. 2), or a gas-engine-powered sprayer on bicycle wheels with a 5-meter boom (fig. 3). The choice of sprayer was dictated by convenience and the muddiness of the field.

EXPERIMENTS AND RESULTS

1957 Experiment

Procedure. The prepared field was planted with Milfor 6(2) on June 4, 1957 at the rate of one cavan per hectare. In this cropping season, the writers set out to find the relative effectiveness of DOW Premerge at 6.7 kg. per hectare and LV-4 at 1.12 kg. of acid

Fig. 1.—A knapsack sprayer with a 2-meter boom.

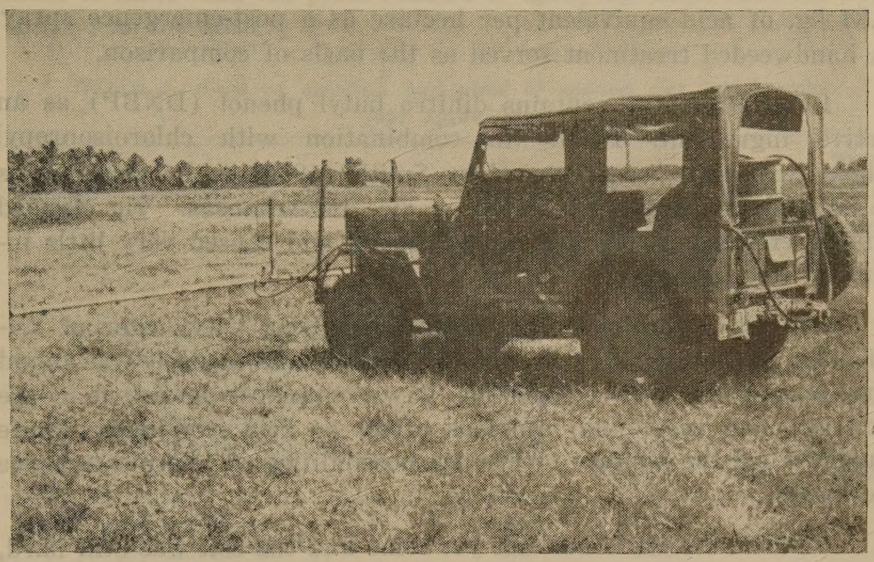

Fig. 2.—A jeep mounted 5-meter boom power sprayer.

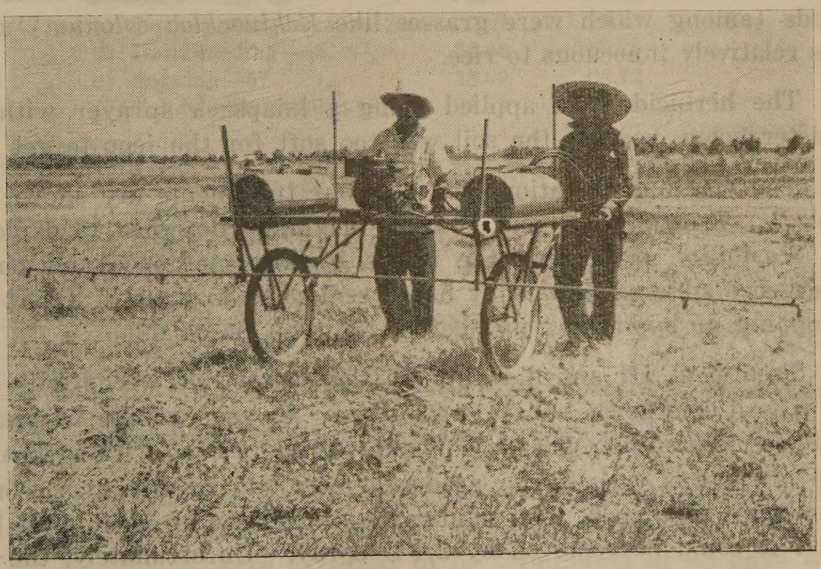

Fig. 3.—A "rigged-up bicycle sprayer" with a 5-meter boom.

equivalent per hectare as pre-emergence treatments, and Kuron at 0.84 kg. of acid equivalent per hectare as a post-emergence spray. A handweeded treatment served as the basis of comparison.

DOW Premerge contains dinitro butyl phenol (DNBP) as an active ingredient. DNBP in combination with chloroisopropyl phenylcarbamate was reported by Smith (1956) to be effective as a delayed pre-emergence spray on rice in Arkansas. He claimed that it effected 95 per cent grass control and caused very little injury to rice seedlings.

LV-4 is a formulation of propylene glycol butyl ester of 2,4-dichloro phenoxyacetic acid. In the preliminary trials it was found that among the 2,4-D compounds, it was the most persistent in the soil and had very mild injurious effect on rice seedlings. These qualities led the writers to test its possibilities as a pre-emergence herbicide.

Because the rains had not yet come and the soil was still hard, these two pre-emergence sprays were applied using the jeep-powered sprayer.

Kuron is a trade name for 2,4,5-trichlorophenoxypropionic acid. It was considered as one of the best post-emergence herbicides for rice because, in the preliminary experiments, it was highly toxic to weeds (among which were grasses like *Echinochloa colonum*) and was relatively innocuous to rice.

The herbicide was applied using a knapsack sprayer with a 2-meter boom, because the soil was too soft for the jeep to get in.

The weeding operations for the four treatments are shown in table 1. Treatments I and II were originally designed to explore the feasibility of keeping the weeds by pre-emergence and post-emergence sprays followed by handweeding at 45 days in a sort of "mopping up operation" just before the crop closed in.

Treatment III aimed to kill all the susceptible weeds with an early post-emergence spray at 21 days. As soon as the herbicide had deteriorated, the plots were harrowed and seeded with soybeans. The latter was expected to produced a ground cover which would keep down the weeds. The legume was considered an ideal cover because it could be removed by 2,4-D spray. Unfortunately, the legumes did not produce a good stand and it was thought more expe-

dient to handweed the plots instead of spraying them with 2,4-D at 45 days as intended.

TABLE 1.—*Cost of weeding and yield of upland rice per hectare 1957 experiment*

TREATMENT NUMBER	OPERATION AND AGE OF RICE WHEN MADE	MAN DAYS SPENT PER HECTARE	COST OF MATERIALS AND LABOR PER HECTARE	YIELD PER HECTARE	WEED COUNTS 17 DAYS AFTER PLANTING PER SQ.M.
			pesos	*cavans*	
I	a) DOW Premerge—2 [a]	0.52	1.30 [b]		
	b) Kuron—35	0.52	8.24 [c]		
	c) Handweeding—45	39.35	98.38 [d]		
	d) Roguing—57	3.37	8.42		
	e) Handwriting—90	75.44	188.60		
			₱304.94	34.15	89.9
II	a) LV-4—2	0.52	10.55		
	b) Kuron—35	0.57	8.36		
	c) Handweeding—45	24.09	60.23		
	d) Roguing—57	3.85	9.62		
	e) Handweeding—90	77.31	193.28		
			₱282.04	18.30	111.7
III	a) Kuron—21	0.45	8.06		
	b) Harrowing—29	2.69	6.72		
	c) Seeding with legume—29	0.27	9.79		
	d) Handweeding—45	23.68	59.20		
	e) Roguing—57	13.09	32.72		
	f) Handweeding—90	89.59	223.98		
			₱340.47	20.94	544.0
IV	a) Handweeding—23	25.16	62.90		
	b) Handweeding—45	39.80	99.50		
	c) Roguing—57	3.09	7.72		
	d) Handweeding—90	86.58	216.45		
			₱386.57	37.41	635.2

[a] Age in days after planting.
[b] Does not include cost of Premerge.
[c] Cost of LV-4, Kuron or 2,4-D computed at the current price of 2,4-D amine, ₱15.00 per gallon.
[d] Cost of labor computed at ₱2.50 a day; 8 working hours per day.

Treatment IV was planned to receive two handweedings only—at 23 and at 45 days old. In other words, all weeding operations in all treatments were expected to be terminated at 45 days when the crop was calculated to close in.

TABLE 1a.—*Yield in cavans per hectare (1957)*

	III	I	II	IV	MEAN
	16.61	40.01	12.55	32.98	25.537
	IV	II	I	III	
	34.29	24.81	40.93	27.55	31.895
	II	IV	III	I	
	23.41	59.68	22.18	28.13	33.350
	I	III	IV	II	
	27.53	17.45	22.70	12.66	20.085
Mean	25.460	35.487	24.590	25.330	27.716
		I	II	III	IV
Treatment mean		34.15	18.35	20.94	37.41

Further development in the field, however, argued strongly for weeding of the plots long after the expected close-in time. More and more aguingay (*Rottboellia exaltata*) towered over the rice plants. They were rogued when the crop was 57 days old to forestall a repetition of a sad experience in one preliminary experiment. In that experiment, the crop was plowed under at about booting time because the aguingay which came up about one month later than the crop grew so fast and lush as to smother the crop.

A weed which at first did not cause much anxiety was pulangpwet (*Echinochloa colonum*). It was generally prostrate and thought to be not much of a threat to the rice plants. But so many of them headed so that there was danger that the next year's weed problem would be aggravated. To allay this disconcerting prospect, the writers decided to weed the field when the crop was 90 days old and starting to head.

Weed counts were made and expenses of weeding operations were kept for each treatment.

Weed-count as a criterion of the seriousness of the weed problem is considered quite representative during the initial phases of the experiment and until the crop is about one-month old. After this period, it may not be reliable because the habit of growth of the weed may condition the damage it inflicts on the crop. One viney weed, for instance, may do more damage than several erect single-stemmed weeds; a tufted weed can occupy some ground. Besides this consideration, one is confronted with the impracticability of making the count on some species. A matted species like *Digitaria*

sanguinalis presents the difficulty of deciding where one plant ends and the next plant begins. It was decided therefore that some indirect criterion had to be resorted to. Man-hours of weeding was considered a likely possibility. Of course, it is recognized that the time spent in weeding a given area is an indication not only of the density of weeds but also of the efficiency of the worker. But when the same group of workers is used to weed the different treatments, probably the variability due to the workers would cancel out. In regarding the figures, it may be worthwhile to remember these considerations.

Results. The density of weeds in the various treatments (table 1) argue very strongly in favor of the pre-emergence treatments. The weeds were reduced to about seven times that of the untreated plots (treatments III and IV). However, the writers could not be very enthusiastic over this because there was a concomitant reduction in the stand of rice with pre-emergence treatment. The average rice stand with Premerge treatment was 71.4 per meter-row and that with LV-4 was 50.8, while the untreated plots had 81.6 plants per meter-row. This is not to consider extensive areas which had no rice plants at all. These were low places where rain water from adjacent places drain into. It is of course obvious that a reduced rice stand is undesirable because the uncropped spots will soon be occupied with weeds and result in a more serious weed problem. Even if this does not happen ,the reduced stand will most likely result in a reduced yield, because upland varieties have low capacity to tiller.

As mentioned in the procedure, aguingay was rogued when the crop was 57 days old. Aguingay emerged about one month later than the rice crop so that it was not represented in the weed count in table 1. But it grew very fast so that in about 25 days, it was able to surpass the rice crop in height. It was most conspicuous because it was darker green than rice and it was more stiff. Judged by the man-hours spent in roguing each plot, the heaviest infestation in treatment I occurred in replication 3; in treatment II, replication 1; in treatment III, replications 2, 3 and 4; and in treatment IV, replications 2 and 4.

Pulang-pwet (*E. colonum*) was known to be a prostrate weed and did not attract much concern. It was however found that in competition with rice, it grew erect. At 60 days after planting, rice was only 72 cm. tall, while pulang-pwet was 74 cm. tall and in ad-

vanced fruiting stage. Because it posed a threat, the writers decided to weed the field thoroughly. The operation was started when the crop was 75 days in age and lasted until it was 90 days old.

Also, at about 60 days of age, a general yellowing and drying of leaf tips became apparent in certain spots. The drying of leaves grew more and more severe so that at 79 days, the place looked like a desolate field of hay. It was suspected that the strong winds which occurred when the crop was about 45 days old had something to do with it, but more observations are needed to verify the suspicion.

The crop was harvested on October 14, 1957 (tables 1 and 1a). It can be seen that the greatest expense in weeding was incurred in treatment IV. This was compensated for by the relatively greater yield in the treatment. The weeding cost per cavan in this treatment was ₱10.30. The lowest cost of weeding the plots was obtained in treatment II, but it also had the lowest yield; hence the unit weeding cost was ₱15.40 per cavan (₱282.04/18.3). The weeding costs per cavan in the other treatments were ₱8.80 for treatment I and ₱16.80 for treatment III. This last treatment was the most expensive probably because of miscalculation in planning the treatment. There was very little time allowed between spraying the 2,4-D and seeding with the legume. As a consequence, many of the seedlings were adversely affected by the herbicide. A preferable procedure would probably be to plant the legume and the crop simultaneously.

Weeding seemed to be most urgent from the time the weeds and crop emerged (about 10 days after planting) up to 45 days of age when the crop closed in.

It may be concluded from this experiment that Premerge and LV-4 are not very desirable as pre-emergence herbicides. Of the two, Premerge seems to be better. One reason why the results in this experiment differed from those of Smith (1956) could be that there was heavy rain a few days after the application of Premerge. The herbicide was carried by the rain down to the germinating rice seed and adversely affected the latter.

1958 Experiment

Procedure. The land was prepared in the usual manner and 1.5 cavans per hectare of Milfor 6(2) was drilled in rows 35 cm. apart on June 8, 1960.

Because the pre-emergence treatments did not give encouraging results, it was decided to forego further tests with them in this experiment.

Treatment I was given a spray of Kuron (0.84 kg. per hectare) when 25 days old, and the weeds that survived were "mopped up" when the crop was 40 days old (table 2). The late spray was expected to be less harmful to the rice plants than the very early spray, but it is also less damaging on the weeds. It may, however, inhibit the weeds so that the latter would not compete effectively with the crop.

Treatment II had a spray of Kuron (0.84 kg. per hectare) at 16 days of age. It was then handweeded at the age of 29 days and given another Kuron spray of the same dose when 46 days old. The last spray was aimed at establishing a sterile cover on the ground at about close-in time. It was also expected to kill the susceptible weeds which had come up since the previous handweeding, or inhibit the less susceptible ones. This second dose of Kuron was given with some diffidence although a previous study (Velasco, Vega and Llena, 1958) indicated that repeated spraying had no adverse effect on grain yield. The first spraying in treatments I and II were expected to give some indications of the relative merits of early and late herbicide applications as regards weed populaton and rice stand.

Treatment III was the second attempt to use legumes as ground cover to prevent the emergence of weeds. The plots were harrowed when 16 days old and seeded with mungo. They were again harrowed at 28 days and handweeded at 39 days. The plan was to keep the legumes until 40 to 45 days and dispose of them by a Kuron spray. This was not followed because the legumes did not cover the ground uniformly and the weeds were growing fast in the uncovered area.

Treatment IV was handweeded twice, at ages of 18 and 47 days.

Results. Weed counts for the different treatments are presented in table 2. In treatment I, the weeds were not counted at 17 days but it may be presumed that the figure could be in the same order of magnitude as those in treatments II to IV. The weeds in treatment II averaged 61.8 per square meter in the four replications. Of these weeds, 21.8 were *Amaranthus spinosus;* 17.2, *Eleusine indica;* 15.3, *Cyperus rotundus;* 11.7, *Digitaria sanguinalis,* 6.5, *Celosia argentea;* 4.7, *Echinochloa colonum;* and the rest were *Rottboellia exaltata, Calopogonium muconoides, Commelina benghalensis, Ipomoea triloba, Euphorbia hirta, Portulaca oleracea,* and *Corchorus*

TABLE 2.—*Cost of weeding and yield of upland rice per hectare*
1958 experiment

TREATMENT NUMBER	OPERATION ANG AGE OF RICE WHEN MADE	MAN DAYS SPENT PER HECTARE	COST OF MATERIALS AND LABOR PER HECTARE	YIELD PER HECTARE	WEED COUNT (NUMBER PER SQ. M.)									
					17 [a]		24		39		46		80	
					T [b]	G [c]	T	G	T	G	T	G	T	G
			pesos	*cavans*										
I	a) Kuron—25 [a] b) Handweeded—40	0.33 37.66	7.76 94.15											
			₱101.91	47.20	—	—	82.6	34.7	33.1	21.7	—	—	9.8	2.3
II	a) Kuron—17 b) Handweeded—30 c) Kuron—46	0.31 26.16 0.31	7.71 65.40 7.71											
			₱80.82	54.89	61.8	11.2	37.3	25.9	—	—	70.8	19.5	6.7	2.3
III	a) Harrowed and planted with mungo—17 b) Harrowed—27 c) Handweeded—39	1.82 2.69 66.34	4.55 6.72 165.85											
			₱177.12	56.92	47.3	14.9	—	—	—	—	—	—	10.1	2.8
IV	a) Handweeded—18 b) Handweeded—47	27.28 74.98	68.20 187.45											
			₱255.65	66.61	47.2	11.4	—	—	52.3	21.7	—	—	8.0	1.3

[a] Age in days after planting.
[b] T = total number of weeds.
[c] G = number of grass weeds.

capsularis. This was mentioned to give a rough idea of the composition of the weed population. The other treatments had about the same distribution of weed species.

At 80 days of age, treatment I had 9.8 weeds per square meter. *C. rotundus* made up 4.6; *E. indica*, 1.3; and the others, which averaged less than one each, were *E. colonum, R. exaltata, Cyperus iria, D. sanguinalis, A. spinosus, Oldenlandia corymbosa, C. muconoides, C. benghalensis, I. triloba, P. oleracea* and *Malvastrum coromandelinum*.

R. exaltata and *E. colonum*, which were dominant in the 1957 experiment, were relatively inconspicuous this year.

In terms of weeding cost and grain yield, late herbicide application in treatment I was less effective than the early application in treatment II. In the first place, the weeds might have exerted their deleterious effect on the crop. Secondly, the weeds could have been well established at the time of spraying so that they succumbed less to the herbicide. Consequently, the cost of hand-weeding was much higher in treatment I.

Treatment III was not effective. Harrowing the field at that stage of the crop resulted in the loss of many rice plants. Although it was especially designed to get the weeds and skip the rows of rice, the harrow did not work consistently well because the rows were not regular and it was quite hard to guide it closely.

The crop was harvested on October 20, 1958. The yields from the different plots are presented in table 2a. Mean squares for rows, columns and treatment were significant at one per cent level. This may be interpreted to mean that there was fertility gradient in the field and that there was an effect of treatment on grain yield. Cost of weeding per cavan in treatment II was ₱1.47 while those for treatments I, III and IV were ₱2.16, ₱3.11, and ₱3.83, respectively. The lowest cost in this experiment is only 16 per cent of the lowest in the 1957 experiment. The reduction in cost might have come about as a result of a more effective weeding schedule or a lighter weed infestation.

It is felt that treatment II deserves further trial and improvement.

TABLE 2a.—*Yield in cavans per hectare (1958)*

	III	I	II	IV	MEAN
	57.638	58.015	64.306	66.558	61.629
	IV	II	I	III	
	66.305	63.604	51.372	49.188	57.617
	II	IV	III	I	
	48.556	67.613	56.867	33.481	51.629
	I	III	IV	II	
	45.939	63.967	65.950	43.096	54.738
Mean	54.609	63.299	59.624	48.080	56.403
		I	II	III	IV
Treatment mean		47.202	54.890	56.915	66.606

Analysis of variance

SOURCE OF VARIANCE	DF	SS	MS	COMPUTED F-VALUE
Total	15	1544.78		
Rows	3	217.40	72.47	10.75
Columns	3	521.66	173.89	25.80
Treatment	3	765.30	255.10	37.85
Error	6	40.42	6.74	

HSD for rows, columns or treatment at 1% level = 9.14

1959 Experiment

Procedure. The upland rice crop occupies the field from May to October. In the following months up to February, there usually is enough rain and moisture in the soil to sustain a short-season crop. If the land is laid fallow after the rice, weeds grow rank and aggravate the weed problem in the following season. In order to obviate this, the writers decided to make it a practice of following the rice crop with a legume crop. This started after the 1958 rice crop. Mungo was planted on November 20, 1958, and harvested on January 27, 1959. No experimental treatments were made on the legume in order to avoid confounding effects on the rice crop.

The field was plowed on January 29 and left in this condition until May 8 when it was plowed a second time. It was disc-harrowed on May 15, and seeded with the variety Azucena at 1.5 cavans per hectare.

Weed-control operations are outlined in table 3. Treatment I

TABLE 3.—*Cost of weeding and yield of upland rice per hectare*
1959 experiment

TREATMENT NUMBER	OPERATION AND AGE OF RICE WHEN MADE	MAN DAYS SPENT PER HECTARE	COST OF MATERIALS AND LABOR PER HECTARE	YIELD PER HECTARE	STAND OF RICE AT 36 DAYS [b]	WEED COUNT (NO. PER SQ. M.)					
						14 [a]		25		32	
						T	G	T	G	T	G
			pesos	*cavans*							
	a) Spud weeded—11 [a]	5.6	14.00								
	b) Sprayed with Kuron—15	0.2	7.44								
I	c) Sprayed with 2,4-D—27	0.2	7.44								
	d) Spud weeded—33	9.4	23.50								
			₱52.38	46.4	63.3	132.8	32.0	243.2	62.4	268.8	51.2
	a) Sprayed with Neburon—1										
	b) Sprayed with Kuron—19	0.2	7.44								
II	c) Spud weeded—26	11.2	28.00								
	d) Spud weeded—39	12.5	31.25								
			₱66.69	49.7	72.7	201.6	142.4	225.6	142.4	110.4	44.8
	a) Spud weeded and Kuron sprayed—15	7.3	25.19								
III	b) Sprayed with 2,4-D—27	0.2	7.44								
	c) Spud weeded—33	9.5	23.75								
			₱56.38	47.1	68.3	252.8	116.8	233.6	68.8	248.0	62.4
	a) Handweeded—19	45.5	113.75								
IV	b) Handweeded—34	31.7	79.25								
			₱193.00	52.4	66.6	—	—	105.6	62.4	136.0	76.8

[a] Age in days after planting.
[b] Stand of rice represents number of plants per meter row.

was a variation of treatment II in the 1958 experiment. Spud-weeding at 11 days was intended to rid the field of the young weeds.

Spud-weeding was chosen because it was more efficient in killing the small emergent weeds than either the wheel-hoe or hand-weeding. A spud is illustrated in figure 4. The Kuron spray (0.84 kg. per hectare) at 15 days was to kill the remaining weeds that might have been just dislocated by spud-weeding. But more important than this, it was meant to produce a sterile cover so that weeds would not come up. The 2,4-D amine (0.84 kg. per hectare) spray at 27 days was to supplement the sterile cover, and, of course, to kill the susceptible weeds that may be present. Spud-weeding at 33 days was a sort of "mopping-up" operation before the crop closed in.

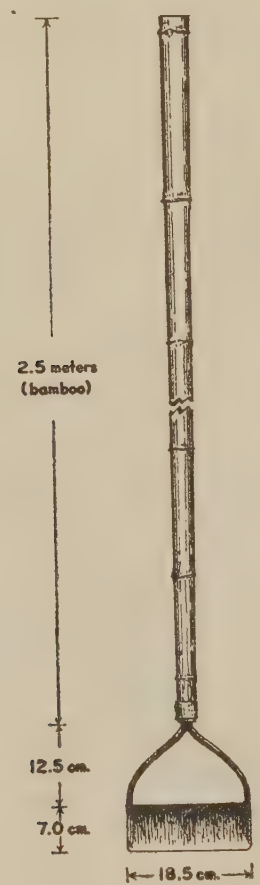

Fig. 4.—A spud used in the experiment.

Treatment II was another attempt to use a pre-emergence herbicide soon after planting. Neburon was applied at 2.24 kg. per hectare. Preliminary tests (Vega and Llena, 1959) showed that Neburon [1,n-butyl,3(3,4-dichlorophenyl),1-methylurea] was very promising. It was less soluble than CMU [3-(p-chlorophenyl)-1,1-dimethylurea], its potent homologue.

The plots were subsequently sprayed with Kuron at 19 days and spud-weeded at 26 and 39 days.

Treatment III was a variation of treatment I. The plots were spud-weeded at 15 days and sprayed with Kuron soon after. If this is advantageous, the two operations may be made by one implement, possibly a tractor-drawn cultivator and sprayer. The 2,4-D amine at 27 days was to maintain the sterile cover, and spud weeding at 33 days was to kill the escapes so that these weeds would not come to seed.

Treatment IV was handweeded at 19 and 34 days.

All the post-emergence sprays in this experiment were applied using a rigged up gas-engine-powered sprayer of the writers' design. It was more manageable and put to greater use than the jeep-powered sprayer.

Results. The Kuron spray at 15 days of age in treatments I and II was followed by 29.5 mm. of rain barely three hours after the application. The intended sterile cover was washed away and weeds were soon coming up. This necessitated another spraying at 27 days.

Neburon was not as effective at it was in the preliminary experiment. Experience indicates that to be effective, it needs sufficient amount of water and to keep its potency, it must not be overexposed to sunlight. It seemed that lack of rain and the successive bright days following application brought about its ineffectiveness in this treatment.

The weed-counts at various ages of the crop are presented in table 3. The number of weeds was almost the same throughout the observation period. This was in contrast to the weed count in an undisturbed plot where weeds tend to diminish with time. The decrease may be attributed to competition among weeds and eventual elimination of weak ones. But in this experiment, there was not much chance for competition because weeds were eliminated by the weeding operations; hence, each count represented a new crop of weeds.

TABLE 3a.—*Yield in cavans per hectare (1959)*

	III	I	II	IV	MEAN
	48.917	50.647	52.112	52.578	51.063
	IV	II	I	III	
	52.348	47.771	52.485	49.514	50.529
	II	IV	III	I	
	53.007	53.366	47.027	38.450	47.962
	I	III	IV	II	
	44.006	42.829	51.299	46.000	46.033
Mean	49.569	48.653	50.730	46.635	48.896
		I	II	III	IV
Treatment mean		46.397	49.722	47.071	52.397

Analysis of variance

SOURCE OF VARIANCE	DF	SS	MS	COMPUTED [a] F-VALUE
Total	15	277.78		
Rows	3	65.72	21.91	1.53
Columns	3	35.95	11.98	0.84
Treatment	3	90.07	30.02	2.09
Error	6	86.04	14.34	

[a] Insignificant.

There was apparently no difference in rice stand among treatments. Treatment II was expected to have a slightly lower count but this did not happen because Neburon seemed to have been largely inactivated.

Yields of grains in the different plots are presented in table 3a. Mean squares for rows, columns and treatments were not significant. There is no visible explanation which can reconcile this observation with that of the 1958 experiment.

Cost of weeding per cavan in treatments I, II, III, and IV were ₱1.13, ₱1.34, ₱1.19 and ₱3.68, respectively. Cost per cavan in treatment II should be greater than ₱1.34 per cavan, but the cost of Neburon was not ascertained, hence, not included in the computation. Treatments I and III deserve further trial.

DISCUSSION

1. The first time this experimental lot was assigned to the department, it was overrun with *Andropogon halepensis* and heavily seeded with *Rottboellia exaltata*. The former was largely minimized by repeated plowing during the preliminary experiments. The latter persisted for some time and caused one preliminary experiment to be plowed under because this weed had completely overpowered the rice. Even the 1957 experiment was largely bothered by it, causing an unreasonably high cost of weeding. It is persistent because the seeds have varying degrees of dormancy. As a result, their germination is staggered. The conditions affecting the breaking of dormancy further stagger germination. Seeds buried deep in the soil remain dormant for many years. They have to be brought up to the surface and exposed to the weathering action of the sun and air before they would respond to favorable moisture in the soil.

The weed was observed even in the 1959 and the 1960 experiments but it has been largely decimated by the regular practice of plowing and weeding and not allowing the plants to come to seed.

2. Observations in these experiments confirmed the general experience of workers that one weeding practice which tends to eliminate one weed species may abet directly or indirectly the multiplication of another. In the course of these experiments, the weed population shifted from one dominated by *Rottboellia exaltata* to another dominated by *Echinochloa colonum*. (In the 1960 experiment, *Leptochloa filiformis* was very conspicuous.) *Eleusine indica, Digitaria sanguinalis, Amaranthus spinosus* and *Celosia argentea* were always present but did not pose a major threat.

3. The handweeded plots (treatment IV) varied in cost of weeding from ₱386.57 per hectare in the 1957 experiment to ₱255.65 in 1958 and ₱193.00 per hectare in 1959. Although the change may be attributed to several factors, it is believed that the decreasing cost is largely due to a diminishing severity of the weed problem. It is hoped that through a continuing wise management practice, the weed problem can be greatly minimized. If this can be attained, mechanized upland rice production will no longer be a remote possibility in this country.

4. Pre-emergence herbicides were found effective in temperate countries, especially in continental areas. This is probably because rain constitutes but a minor fraction of the total precipitation in

these places. In the Philippines, the use of pre-emergence herbicides has been rather disappointing. Our rains come when least expected and carry the herbicides down to the zone of the germinating seeds. Because these herbicides are generally non-selective, they kill the germinating rice seeds just as effectively as they do the weeds, resulting in big vacant spaces which are usually impractical to replant.

5. These experiments show that the most feasible and economical system of weeding is a schedule which makes use of chemicals, mechanical methods, and cultural practices. The field is spud-weeded at 10 to 15 days after planting. It should be done as soon as all the rice seedlings have emerged and the tilth of the soil would allow the use of the spud. 2,4-D spray is applied concurrently or a few days after weeding. Depending upon the stand of the weeds which subsequently germinate, a second spray of 2,4-D may be necessary 10-20 days after the first spraying. At about the time the plants close in (i.e., the leaves of plants from adjacent rows overlap), a thorough spud-weeding coupled with hand-weeding is made in order to minimize the number of weeds that flower and come to seed. With most upland rice varieties the last weeding may be done at 45 days after planting. A good top dressing of nitrogen during the first month hastens the growth; hence, the plants close in earlier.

To further minimize the weed problem the land should be occupied by some crop throughout the period that there is enough moisture in the soil to sustain plants. If, for any reason it has to be laid fallow, it should be plowed occasionally to prevent weeds from coming to seed.

6. The writers learned an important incidental lesson in their 1960 experiment, which, although irrelevant, is worth recording here. In this season, they planted Rexoro-delitus, a short, sparingly vegetative and relatively heavy grain-bearing variety. It was considered very desirable for mechanized upland rice production, because it does not lodge easily; its shortness and its high grain-to-straw ratio makes it suitable for harvesting with a combine. They somehow overlooked or minimized the need for a fast-growing crop which can close in and shade the open spaces in a short time. Despite their having planted the variety in rows 17 cm. apart (one-half the distance of the rows for Milfor and Azucena), the crop failed to grow into a dense cover. As a result, weeds continued germinating and bothering the crop even up to harvest. This experience emphasizes the need for a vigorous-growing upland variety.

7. The writers feel that 2,4-D spray has to be used sparingly, despite their finding in an earlier paper (Velasco, Vega and Llena, 1958). They found that repeated spraying with 2,4-D did not decrease the yield of rice. Although 2,4-D is known to adversely affect tillering of rice (de la Fuente, Fertig and Llena, 1956; Vega and Obien, 1960), this did not affect the yield in their experiment because their plants, having been drilled, were not expected to tiller very much, anyway. However, their more recent observations were that 2,4-D has a direct adverse effect on yield of some varieties. In addition, because the root system was poorly developed and weak, the plant may not withstand strong winds and drought. It is felt that further study on this aspect is needed.

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A STUDY OF THE MORPHOLOGY AND SOME PHYSICAL PROPERTIES OF COCONUT SOILS IN LAGUNA [1]

D. A. Carandang, R. C. Bruce, Q. V. Marcaida,
and O. P. Peñaflor [2]

WITH THREE TEXT FIGURES

The morphological characteristics of a good coconut soil in Tipunan, Magdalena, were similar to those of a poor coconut soil in the same locality. In three other locations, San Agustin, Alaminos; Del Remedio, San Pablo City; and Duhat, Santa Cruz, variations in morphology were observed in all aspects from depth to characteristics of the different horizons. In spite of the variations in the morphology of the soils studied, root distribution assumed a similar pattern in all locations.

Water table was encountered at a depth of 90 centimeters in the good coconut area of Tipunan, Magdalena. Thus, water-logging was not the probable cause of yellowing in this location.

Values for bulk density decreased with depth while moisture equivalent increased with depth. Differences in bulk density and moisture equivalent between good and poor coconut soils were not significant to affect root distribution and yield of trees. The yellowing of coconut trees in the areas studied may be the resultant effect of the interaction of soil fertility, physical properties of the soil and other factors as yet undetermined.

The coconut has always been one of the most important cash crops of the Philippines. During the war, the coconut industry was seriously damaged and before it could be fully rehabilitated, serious maladies of undetermined causes have destroyed large numbers of coconut trees. The subject of this paper involves studies of some physical properties of soils where coconuts are exhibiting yellowing of leaves. This yellowing is not the same as the yellow-mottle decline (cadang-cadang) described by Celino (1947a) in the Bicol region. The yellowing described in this report is found in coconut grooves of San Pablo City, Santa Cruz, and Alaminos, Laguna; Tiaong, Quezon; and Lipa City, Batangas. Marked yellowing in trees results in reduced yields and in some cases, death. Since yellowing

[1] Central Experiment Station Contribution No. 2063.

[2] The writers are grateful to Dr. Marlin G. Cline, former visiting Professor of Soil Science, for his guidance in the course of this investigation.

is found in spots which are close to normal trees, it was advanced that unfavorable soil physical conditions might be responsible for the poor growth of the trees.

According to Celino (1947b), the yellowing of coconut leaves in Laguna was common in areas that were generally water-logged and where the soil was a shallow, heavy clay underlain by a dense subsoil. Reinking (1950) attributed the yellowing in certain sections of Candelaria, Quezon, to nutrient deficiency. In places where yellowing occurred in the absence of cogon and other weeds, the presence of hardpan, poor drainage, high water table or unfavorable soil types were suggested as the possible causes of the malady. Fajardo (1953) claimed that many plantations in Laguna were free from yellowing when coconuts were planted in deep, well drained, sandy loam or clay loam soils, and where the plantations were given good care and attention.

Escritor (1954) attributed the low yield of coconut in Gumaca, Quezon to low potassium content in the soil. The poor coconut soil has a pH of 6.10, 2.38 per cent organic matter, 32.49 ppm. P; 0.14, 13.48, and 9.68 me. K, Ca, and Mg. per 100 grams of soil, respectively. Felizardo and Galvez (1960) found that fertilizer application and/or digging alone improved the yield of poor coconut in Duhat, Sta. Cruz. The soil in this area has a pH of 6.05, 4.42 per cent organic matter, 18.10 ppm. P; 0.84, 7.95, and 4.0 me. K, Ca, and Mg. per 100 grams of soil, respectively.

This report summarizes the studies conducted to determine whether or not unfavorable soil physical properties inhibit root development and are responsible for the poor growth and yellowing of coconut trees in San Agustin, Alaminos; Del Remedio, San Pablo City; Duhat, Santa Cruz; and in Tipunan, Magdalena, all in Laguna province.

Description of the plantation. The plantations used in this study vary in topography from level in Sta. Cruz, Magdalena, and San Pablo to undulating in Alaminos. The undergrowth were weeds mostly cogon, amor seco (*Andropogon asciculatus* Retz.), and mutha (*Cyperus rotundus* Linn.). Payang-payang (*Flamingia strobilifera* (Linn.) R. Br.) and takpo (*Ardisia squamulosa* Presl.) were abundant in Alaminos. Some fruit trees like santol (*Sandoricum koetjape* (Burm. F) Merr.) and guava (*Psidium guajava* Linn.) were also found in most of the places studied.

One-fourth hectare of the productive and a similar area of the unproductive plantations with a distance of not more than 200 meters apart were selected for this study. Five trees in each area were picked at random. According to the information supplied by the farmers, the average annual yield in nuts per tree for the poor area ranged from 30 to 55 and for the good area, 65 to 75.

Soil profile. Five pits, each one meter wide and two meters long, with varying depths (depending on the depth of the parent material), were dug in each area. Each pit was dug with the inside face three meters from the experimental tree.

The profiles were described according to the Soil Survey Manual of the United States Department of Agriculture (1951). Horizon boundaries were plotted to scale on a cross-section paper.

Root distribution. Cords were tied horizontally and vertically across the profile (Fig.1) at 15-centimeter intervals to form a grid. Roots were counted in each section of this grid by size-classes designated as small (less than 2 mm. in diameter), medium (2 to 5 mm.) and large (greater than 5 mm.) Roots were plotted on the same cross-section paper used for horizon boundaries.

Collection and analysis of soil samples. Duplicate clod samples were collected from each major horizon for bulk density determination (Shaw, 1916). Bulk samples from the same horizons were collected, air-dried, and sieved. Moisture equivalent was determined by the method described by Piper (1950).

RESULTS AND DISCUSSION

Description of the yellowed coconut tree. In the early stages of yellowing, tthe longest three pairs of leaves assumed a faded green color, much lighter than that of the normal leaves. The older leaves were generally more pronouncedly yellow. The youngest leaf was always shorter than the older ones, giving the crown a tapered appearance. In the advanced stage, the older three or four pairs of leaves turned brownish yellow or dull yellow, starting from the tip of the pinnae and decreasing toward the midrib. The leaves appeared to starve and then dropped prematurely. Only a few pairs of short tufted, light green leaves were left on the crown. No fruit developed at the last stage of the condition.

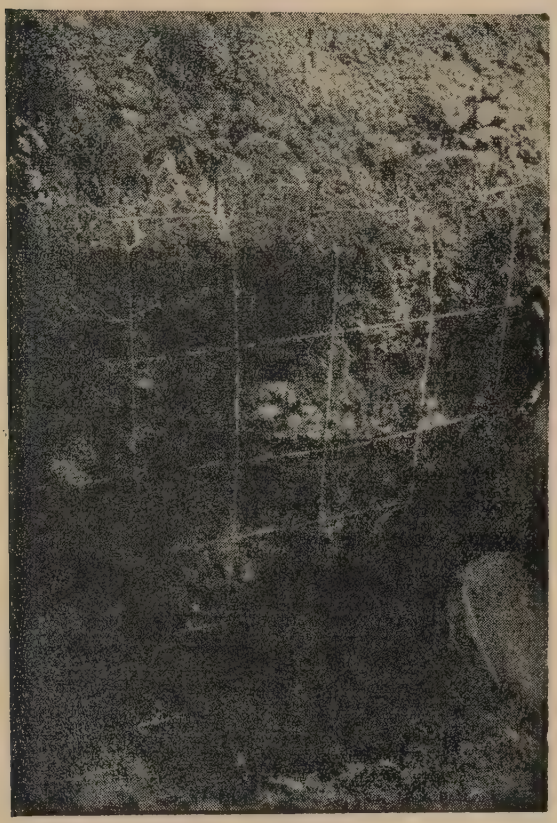

Fig. 1.—Side of a pit showing how the number and distribution of coconut roots and the horizons of the profile were plotted.

Description of soil profile. In the four locations studied, the five profiles described in each of the good and poor areas were similar except for minor variations in the thickness of horizons, color, pH, and other characteristics typical of normal soil variability within a limited area. The soil profiles representing the good and the poor coconut plantations were different except in Magdalena where they had practically the same kind and arrangement of horizons.

Since the four areas studied were mapped under Lipa series (Alicante *et al.*, 1948), a modal profile for the four areas is presented below.

The differences in the horizons between the good and poor areas were not associated with differences in root distribution of coconut growing in the two soils.

Horizon	*Description*
A	0–20 cm. dark brown (5 YR 3/2) to very dark grayish brown (10 YR 3/3) silt loam to salty clay loam; moderately developed fine to medium subangular blocks, moderately plastic and slightly sticky; pH 6.5.
B	20–85 cm. dark brown (10 YR 4/3) silty clay loam to clay; moderately developed fine to medium subangular blocks moderately plastic and slightly sticky; pH 6.4.
C	85–115 cm. grayish brown (10 YR 5/2). Tuffaceous parent material.

In Tipunan, Magdalena, water table was encountered 90 centimeters below the surface of the good coconut area. This was observed during the months of March and August. Water table was not encountered in the poor area even at a depth of 100 centimeters. This apparently disproves the theory that the yellowing of coconut leaves in this area was due to water-logging.

Bulk density. The average bulk density near the surface in the four locations ranged from 1.25 to 1.53 gm/cc. for the productive and 1.27 to 1.53 gm/cc. for the unproductive soil (Fig. 2). At the lower depths of the profile the range was 0.93 to 1.44 gm/cc. for the productive and 100 to 1.46 gm/cc. for the unproductive soils.

Very little significance could be attached to the differences in the bulk density values between the good and poor soils because all the figures were within the limits considered favorable for plant growth. It is, however, worthwhile to mention that the values obtained differed from the general observation in temperate regions where the bulk density increases with depth.

Moisture equivalent. The average moisture equivalent near the surface soil in the four locations ranged from 25.95 to 33.06 per cent for the productive and 24.15 to 30.91 per cent for the unproductive. At the lower depths of the profile the range was 22.72 to 50.25 per cent for the productive and 26.30 to 32.79 per cent for the unproductive (Fig. 3).

Moisture equivalent increased significantly with depth. Although there were differences between the moisture equivalents of the productive and unproductive soils, the magnitude of the values for other soils showed that at field capacity they both contained enough moisture in all horizons to support the growth of the plant. This

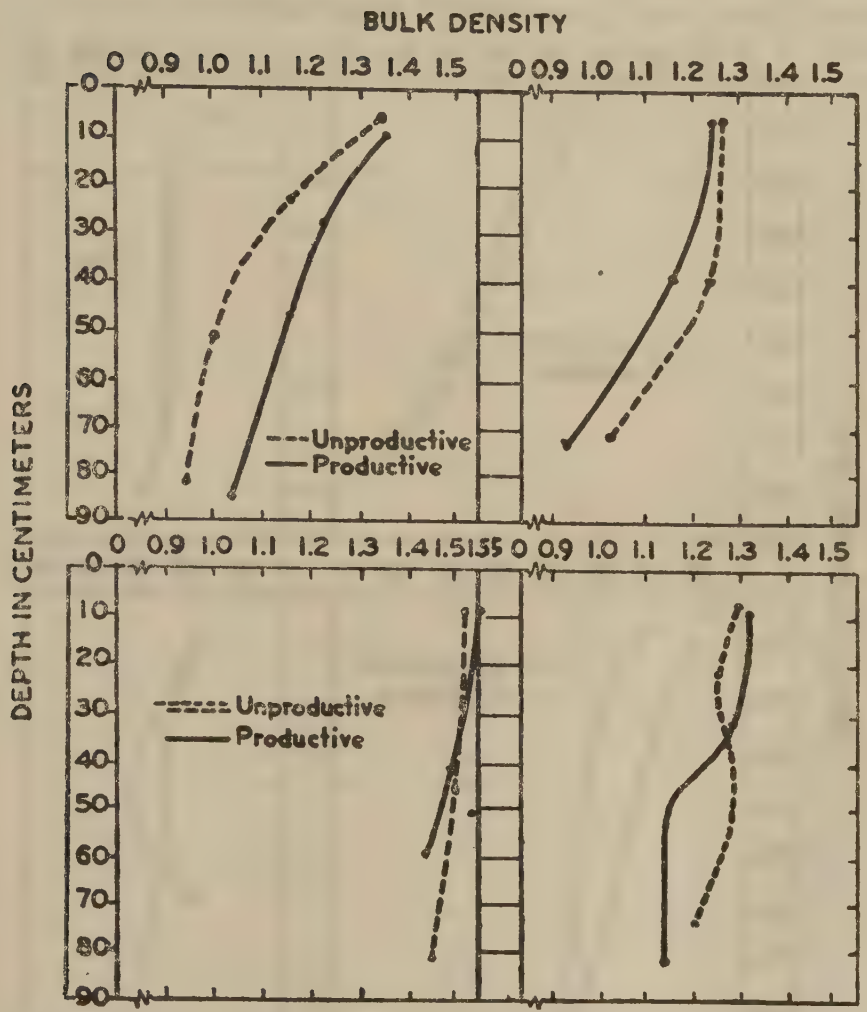

Fig. 2.—Bulk density (gm./cc.) of productive and unproductive coconut soils in (from upper left, clockwise): Alaminos, Magdalena, San Pablo, and Sta. Cruz.

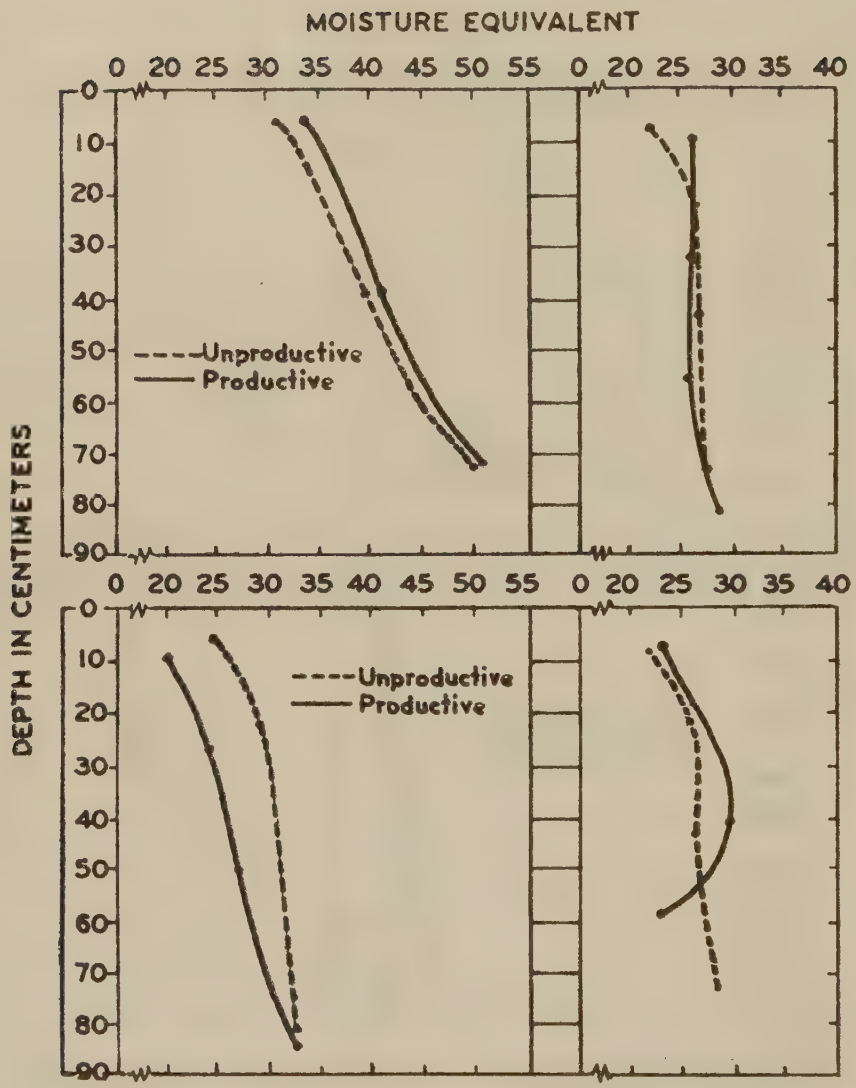

Fig. 3.—Percentage moisture at moisture equivalent in productive and unproductive coconut soils in (from upper left, clockwise): Magdalena, San Pablo, Sta. Cruz, and Alaminos.

indicated that low moisture holding capacity was not the cause of the observed yellowing.

Root distribution. Table 1 shows the root distribution in productive and unproductive soils in fours areas. Comparison of the number of roots for the same depth showed no significant differences between root distributions of all sizes. Likewise, there was no consistent relationship between root distribution and depth of the soil.

TABLE 1.—*Mean number of large, medium and fine roots in relation to soil depth in various areas*

LOCATION	AREA	DEPTH	SIZE		
			Large	Medium	Small
		cm.			
Alaminos	Productive	0–30	32	99	231
		30–75	9	29.4	48
	Unproductive	0–30	25	74	338
		30–75	7	24	884
San Pablo	Productive	0–30	35.2	53.4	175.5
		30–75	21.8	22.8	69.6
	Unproductive	0–30	32.4	35.8	162.2
		30–75	19.4	14.2	45.4
Magdalena	Productive	0–30	44	71	214
		30–60	7	19	74
		60–90	3	8	45
	Unproductive	0–30	44	78	182
		30–60	9	17	38
		60–90	5	17	27
Sta. Cruz	Productive	3–30	49	69	180
		30–60	25	24	57
		60–90	18	19	77
	Unproductive	3–30	56	56	135
		30–60	8	9	48
		60–90	2	10	66

SUMMARY AND CONCLUSION

Soils in four towns in Laguna supporting both productive and unproductive coconut trees in the same area were studied. Five pits were dug in each of the poor and good coconut section. Profiles were described. Root distribution was plotted on cross-section paper to-

gether with horizon boundaries. Bulk density and moisture equivalent were determined and correlated with root distribution and yield.

Morphology and physical properties studied did not reflect the root distribution pattern and could not account for the difference between poor and good coconut areas. In view of the observations made by Felizardo and Galvez (1960) and Escritor (1954) it seems that poor growth and yellowing is an integrated result of factors such as soil fertility, physical properties and other conditions affecting growth of coconut.

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THE GLUTAMIC ACID CONTENT OF SOME AGRICULTURAL PRODUCTS, BY-PRODUCTS, AND WASTES [1]

ELVIRA B. MANZANILLA and APOLINARIO R. CARANGAL, JR.

The glutamic acid content of mature coconut, "sport" coconut, copra meal, rice hull, rice bran ("kiskis"), corn gluten feed, corn cobs, coffee grounds, coffee husk, cacao husk, cacao shell, cowpea, ipil-ipil leaves and seeds, monogo, "cadios", lima bean, "batao", "tapilan", peanut, string bean, kapok seed meal, lumbang seed meal, ramie and abaca sap was determined by a modified procedure. This procedure involves the conversion of glutamic acid to succinic acid, which was separated and determined by column chromatography on the silica gel column.

Of the materials analyzed, copra meal, corn gluten feed, lumbang seed meal, rice bran, rice polish, and kapok seed meal show good potentialities as raw materials in the production of glutamic acid.

Glutamic acid is a prominent constituent of many proteins and, in the form of monodium salt, is a useful raw material in the food industries. This salt is used in the preparation of meats, sea food, stews, soup, etc. It has the quality of accentuating natural flavor and suppressing certain undersirable tastes.

The principal industrial sources of glutamic acid are wheat gluten, Steffen's waste of the sugar beet industry, soybean, and corn gluten. Other sources are zein, peanut flour, casein, cottonseed flour, rice, egg albumin, and yeast.

At present, there is no industrial plant in the Philippines engaged in the production of glutamic acid. Considering our heavy yearly importation of monosodium glutamate, which amounted to about 2.8 million pesos in 1953,[2] it is of importance to determine which raw materials may be tapped for the production of glutamic acid.

This study deals with the determination of the glutamic acid content of some local agricultural products and their by-products by a modification of the method of Cohen and Krebs (Block and Bolling, 1945).

[1] Central Experiment Station Contribution No. 2064.
[2] Data furnished by the Bureau of Census and Statistics, Manila.

MATERIALS AND METHODS

Modification of the Cohen-Krebs method

In the procedure of Cohen and Krebs (Block and Bolling, 1945) as modified by Woodward and co-workers (1941) and Bovarnick (1952), glutamic acid is oxidized with chloramine-T to *beta*-cyanopropionic acid. The latter acid is then hydrolyzed to succinic acid which is determined by a manometric technique using succinic-oxidase (Krebs, 1948). The procedure also involves the ether extraction of the two acids and the preparation of the enzymes from minced pigeon muscles. Block and Bolling have suggested the possibility of using other micromethods for succinic acid, such as those of Goepfert (1940) and Pucher and his associates (1941). These methods and that of Arhimo and Laine (1939) involve the quantitative separation of succinic acid and its conversion to other products, as determined by volumetric or colorimetric methods. The many steps in these procedures make them quite tedious and are possible sources of errors. Bulen, Varner, and Burrell (1952) have devised a procedure for the separation of mixtures of some metabolic organic acids, including succinic acid. The acids are separated by elution through a silica gel column.

It can readily be seen that the procedure of Cohen and Krebs for the separation and determination of succinic acid can be modified by combining Cohen's method and that of Bulen, *et. al.* To establish such a method, experiments were conducted on the determination of succinic and glutamic acids and of the glutamic acid of a protein hydrolyzate.

Separation and determination of succinic acid. Known weights of succinic acid (5 to 10 mg.) with 2 to 3 drops of the phenol red indicator and 5 drops of 0.5 N H_2SO_4 were mixed with the least amount of silica gel to give a free flowing powder. This mixture was transferred carefully into the silica gel column (1.1 x 13 cm.) prepared according to the method of Bulen *et al.* The schedule of the solvent followed was 60 ml. and 100 ml. of the 5 and 15 per cent solvent ($CHCl_3$-BuOH) solutions, respectively, at a rate of about 60 to 80 ml. an hour. The eluate was cut into fractions of 3 ml. The collected fractions were then titrated with 0.01 N NaOH using phenol red as indicator. The recovery of succinic acid was calculated by integrating the titration volume corresponding to succinic acid.

In addition to the calibration of the column with succinic acid, experiments were also conducted where chloramine-T (2 to 3 mgm.), toluenesulfonamide (2 mgm.), and HCl (12.5 per cent, used instead of H_2SO_4) were added separately and in combination with succinic acid. The results of these experiments are presented in table 1.

TABLE 1.—*Recovery of succinic acids on the silica gel column*

RUNS	TRIALS	PER CENT RECOVERY	
			Average
Succinic acid (1–5 mg.)	1	98.6	96.0 ± 1.17
	2	95.8	
	3	96.33	
	4	93.4	
Succinic plus p-toluene sulfonamide (2 mg.)	1	94.3	94.6 ± 1.55
	2	93.8	
	3	97.7	
	4	92.6	
Succinic plus chloramine-T (2 mg.)	1	93.3	94.4 ± 1.17
	2	96.8	
	3	93.2	
	4	94.4	
Succinic acid plus chloramine-T, sulfonamide and HCl	1	95.5	93.7 ± 1.22
	2	92.6	
	3	94.3	
	4	92.3	

Determination of glutamic acid. An aliquot of the glutamic acid solution (5 to 10 mgm., 5 ml.) was adjusted to pH 4.7 with 2 to 3 ml. citrate buffer and oxidized with 2 ml. of the 10 per cent freshly prepared chloramine-T solution by shaking at 40°C for 10 minutes. The solution was cooled in an ice bath and the precipitate was then washed with ice water (2, 5 ml. portions). The filtrate and washings were collected directly into a test tube (2.5 x 20 cm.).

Concentrated HCl was added to the combined filtrate and washings (total volume of about 20 ml.) to give a mineral acid concentration of 12.5 per cent. The solution was placed in a boiling water bath for 15 to 20 minutes. After cooling the hydrolyzate, it was transferred to a 50-ml. beaker and concentrated almost to dryness on a steam bath. Afterwards, this concentrated fraction containing succinic acid was subjected to chromatographic separation and determination as discussed above.

Protein hydrolyzate. In initial experiments using a hyrolyzate and a known weight of glutamic acid, variable and low recoveries were obtained (table 2). Perhaps these poor results were due to the presence of excessive amounts of interfering substances. Passage through Dowex-50 (Na-form) column was then tried to remove the interfering substances.

TABLE 2.—*Recovery experiments on known weights of glutamic acid*

RUNS	WEIGHT OF ACID [a]	TITRATION VALUES [b] 0.0115 N NaOH	RECOVERY	
			Glutamic acid [d]	Per cent
	mg.	*ml.*	*mg.*	
1	8.06	10.25	8.66	107.44
2	5.04	5.78	4.88	96.82
3	5.04	5.86	4.95	98.21
4 [c]	5.04	3.78	3.19	63.29
5 [c]	5.04	3.57	3.01	59.72
6	5.00	4.82	4.07	81.40
7	5.00	5.61	4.74	94.80
8	8.06	9.57	8.08	100.24
9	8.06	9.97	8.42	104.46
10	5.00	5.56	4.69	93.80
11	5.00	5.33	4.50	90.00
12	5.00	4.86	4.10	82.00
13	8.00	10.48	8.85	110.62
14	8.00	9.74	8.23	102.87
15	8.00	10.14	8.56	107.00
16	5.00	6.14	5.18	103.60
17	5.00	5.67	4.79	95.80
18	8.00	9.79	8.27	103.37
		Average		98.27 ± 6.07

[a] Aliquots of 50 ml. solution containing 50.4 mg.
[b] Corrected for the blank.
[c] Spottering during the concentration of the hydrolyzate on the hot plate.
[d] Weight of glutamic acid (mgm.) = ml. of NaOH × .0115 × 73.5.

Solutions of glutamic acid (containing 5 to 20 mg.) were passed through the prepared column. The acid was eluted with 12 to 15 ml. of citrate-buffer of pH 4.7 (0.1 M, prepared by dilution of the buffer used in the oxidation of glutamic acid with chloramine-T). Experiments on the recovery of glutamic acid using known weights of acid with or without the hydrolyzate were conducted after pass-

ing through the Dowex column. Results of these runs are presented in table 3.

TABLE 3.—*Recovery experiment on glutamic and acid hydrolyzate* [a]

(a) *Without passing through Dowex-50 column*

RUNS	SAMPLE [b]	TITRATION VALUES OF 0.0115		RECOVERY OF KNOWN WEIGHT OF GLUTAMIC ACID [c]
		Actual	Theoretical	
		ml.	*ml.*	
	A	5.48	5.88	93.19
I	B	5.64	—	—
	C	8.35	—	46.09
	A	10.36	9.80	105.71
II	B	6.94	—	—
	C	12.36	—	55.30
	A	9.63	9.80	98.26
III	B	5.82	—	—
	C	12.93	—	72.55

(b) *After passing through Dowex-50 column*

	A	6.04	5.88	102.72
I	B	5.36	—	—
	C	10.65	—	90.30
	A	5.48	5.88	93.19
II	B	5.54	—	—
	C	11.15	—	95.40
	A	9.54	9.80	97.34
III	B	5.03	—	—
	C	14.26	—	94.18
	A	9.29	9.80	94.79
IV	B	5.40	—	—
	C	14.32	—	91.02
			Average	94.86

[a] Acid hydrolyzate of rice bran.

[b] A—pure glutamic acid (5–8 mg.)
B—Hydrolyzate (5 ml.)
C—Hydrolyzate plus glutamic acid.

[c] For A $= \frac{\text{Actual}}{\text{Theoretical}} \times 100$; for C $= \frac{(\text{C} - \text{B})\text{ ml. NaOH}}{\text{Theoretical}} \times 100$

Determination of glutamic acid content of some agricultural products and their by-products

Hydrolysis of the material. With the modified procedure, the glutamic acid content of coconut (mature, sport, and copra meal), rice hull, rice bran "kiskis", rice polish, corn gluten feed, corn cobs, coffee ground, coffee husk, cacao husk, cacao shell, cowpea (*Vigna sinensis*), ipil-ipil seeds and leaves (*Leucaena glauca*), mongo (*Phaseolus aureus*), cadios (*Cajanus cajan*), Lima beans (*Phaseolus lunatus*), "batao" (*Dolichos lablab*), "tapilan" or rice bean (*Phaseolus calcaratus*), peanut (*Arachis hypogea,* string bean (*Vigna sesquipedalis*), kapok seed meal (*Ceiba pentandra*), lumbang seed meal (*Aleurites moluccana*), ramie leaves (*Boehmeria nivea*), and abaca sap (*Musa textilis*) were determined. Weighed (1 to 5 gms.) samples were hydrolyzed by refluxing with 50 ml., 10 per cent H_2SO_4 for 40 to 48 hours. In the case of abaca, 25 ml. of the expressed sap was hydrolyzed. The hydrolyzates were filtered off and the precipitates washed with distilled water. The combined washings and filtrates were neutralized with a calculated amount of $CaCO_3$. The neutralized sample was then filtered through a Buchner funnel and the $CaSO_4$ precipitate repeatedly washed with distilled water. The collected filtrates and washings were concentrated to about 5 ml. on a steam bath. This concentrated hydrolyzate was then passed through Dowex-50 column and eluted with the citrate buffer (pH 4.7). Five ml. aliquots of the eluate were used for the determination of glutamic acid. Results were expressed in per cent of glutamic acid of the original sample, moisture and ash-free sample and grams of glutamic acid per 16 grams nitrogen (table 4).

Other determinations. The moisture and ash of the samples were determined according to the AOAC method (table 5). The protein content was determined by a microprocedure used in the Central Experiment Station Analytical Laboratory (U.P. College of Agriculture).

In the case of the abaca sap sample, the per cent of total solid was determined by drying a weighed amount of the sap to constant weight at 80°C.

RESULTS AND DISCUSSION

Modified procedure of determining glutamic acid

The modified procedure eliminates the two ether extractions in Cohen's method. Bovarnick (1952), by using 20 per cent H_2SO_4

instead of HCl for the hydrolysis of the cyanopropionic acid, was able to eliminate the second ether extraction. Table 1 shows that the presence of other substances (HCl, toluenesulfonamide, and chloramine-T) did not markedly affect the recovery of succinic acid (92.3 to 98.6 per cent). These high recoveries, which compare favorably with the findings of Krebs, suggested the elimination of the ether extraction of cyanopropionic acid.

TABLE 4.—*Glutamic acid of some agricultural products*

	MG. OF GLUTAMIC ACID	PER CENT GLUTAMIC ACID		GM. GLUTAMIC ACID PER 16 GM. N_2
		Air-dry basis	Moisture & ash-free basis	
1. Coconut				
a. Sport ("Makapuno")	4.40	0.53	1.41	18.78
b. Mature	3.06	0.55	1.04	13.99
c. Copra meal	5.57	3.34	4.07	11.47
2. Rice				
a. Rice hull	1.60	0.38	0.53	10.60
b. Rice bran ("kiskis")	4.85	1.75	2.42	19.14
c. Rice polish ("binlid")	5.66	1.36	1.73	19.07
3. Corn				
a. Corn gluten feed	8.40	2.00	2.62	17.26
b. Corn cobs	1.67	0.20	0.22	14.53
4. Coffee				
a. Coffee ground	3.98	0.96	1.22	12.04
b. Coffee husk	1.61	0.58	0.66	9.10
5. Cacao				
a. Cacao husk	1.61	0.58	0.71	4.76
b. Cacao shell	3.58	1.29	1.52	13.75
6. Legumes				
a. Cowpea (*Vigna sinensis*)	6.41	2.31	2.61	13.99
b. Ipil-ipil seeds (*Leucaena glauca*)	5.63	3.38	3.92	17.17
c. Mongo (*Phaseolus aureus*)	5.46	3.28	3.64	14.29
d. Cadios (*Cajanus cajan*)	6.24	1.50	1.86	12.53
e. Lima bean (*Phaseolus lunatus*)	4.43	1.60	1.96	14.10
f. "Batao" (*Dolichos lablab*)	5.36	1.29	1.84	15.03
g. "Tapilan" (*Phaseolus calcaratus*)	5.01	2.41	2.74	12.58
h. Peanut (*Arachis hypogea*)	6.21	3.73	4.09	14.24
i. String bean (*Vigna sesquipedalis*)	5.05	1.21	1.37	10.72
7. Kapok seed meal (*Ceiba pentandra*)	5.12	3.07	3.61	11.03
8. Lumbang seed meal (*Aleurites moluccana*)	6.68	3.21	3.70	18.20
9. Ramie leaves (*Boehmeria nivea*)	4.84	1.74	2.09	10.45
10. Abaca sap (*Musa textilis*)	4.68	63.0 mg./gm. total solids		

In the experiments using known weights of glutamic acid (5 to 8 mg.), the recovery ranged from 81.40 per cent to 110.62 per cent, with an average of 98.27 ± 6.07 per cent (table 2). The high average deviation of the mean and the wide range of recovery are probably due to the errors in titration. Such experimental error is possible considering the low concentration of the alkali (0.01 N NaOH) and the immiscibility of the acid solution. The latter may

TABLE 5.—*Moisture, ash and nitrogen content of the different experimental materials*

	PER CENT MOISTURE	PER CENT ASH (Air-dry bassis)	PER CENT NITROGEN (Air-dry bassis)
1. Coconut			
a. Sport ("Makapuno")	62.02	0.57	0.45
b. Mature	46.02	0.77	0.63
c. Copra meal	9.62	10.21	3.05
2. Rice			
a. Rice hull	11.25	16.70	0.58
b. Rice bran ("kiskis")	13.87	13.82	1.46
c. Rice polish ("binlid")	15.50	5.84	1.14
3. Copra			
a. Corn gluten feed	16.68	6.43	1.87
b. Corn cobs	7.58	2.09	0.22
4. Coffee			
a. Coffee ground	17.54	3.92	1.27
b. Coffee husk	6.83	5.96	1.02
5. Cacao			
a. Cacao husk	11.58	6.79	1.95
b. Cacao shell	12.08	3.15	1.50
6. Legumes			
a. Cowpea (*Vigna sinensis*)	6.12	5.27	2.64
b. Ipil-ipil seeds (*Leucaena glauca*)	8.56	5.31	3.15
c. Ipil-ipil leaves (*Leucaena gauca*	17.00	12.05	2.54
d. Mongo (*Phaseolus aureus*)	5.55	4.37	3.67
e. Cadios (*Cajanus cajan*)	13.93	5.41	1.46
f. Lima bean (*Phaseolus lunatus*)	12.24	7.27	1.81
g. "Batao" (*Dolichos lablab*)	9.17	8.93	1.37
h. "Tapilan" (*Phaseolus calcaratus*)	7.58	4.74	3.04
i. Peanut (*Arachis hypogea*)	4.89	4.08	4.19
j. String bean (*Vigna sesquipedalis*)	6.71	4.68	1.81
7. Kapok seed meal (*Ceiba pentandra*)	9.11	5.82	4.46
8. Lumbang seed meal (*Aleurites moluccana*)	6.02	7.21	2.82
9. Ramie leaves (*Boehmeria nivea*)	6.04	10.37	2.67
10. Abaca sap (*Musa textilis*)	Average total solids		1.78

be minimized by using alcoholic alkali for the titration. These results compare favorably with those obtained through the method of Cohen-Krebs and the other modifications.

The chromatographic analysis of succinic acid is much simpler than Cohen's manometric technique or the other micromethods (Goepfert, Pucher and his associates and Arhimo and Laine). The manometric technique of analysis requires special techniques and apparatus, unlike the chromatographic method.

This modified procedure was also found adaptable for the analysis of acid hydrolyzates as shown by results of the recovery experiments (table 3). Preliminary runs without passing the hydrolyzates through the Dowex column gave poor recovery of the added glutamic acid (48 to 72 per cent). Better recovery of the added acid (90 to 97 per cent) was obtained after passing the hydrolyzate through the Dowex column. Runs with only the acid gave a recovery (93 to 102 per cent) comparable to that discussed previously (table 2).

The lack of specificity of this procedure makes it more disadvantageous than the microbiological and the enzymic decarboxylation methods. Some of the acid hydrolyzates such as those from corn cobs, coffee husk, cacao husk and shell, had high titration values for the blanks (acid hydrolyzate) due to the presence of other acids. Bulen *et al.* (1952) mentioned that lactic and succinic acids are eluted out at the same time. Ether extraction of the acid hydrolyzates before analysis with this procedure may greatly minimize this error.

For practical purposes, the liberation of glutamic acid from a natural protein may be followed during the hydrolysis by the employed modified procedure. It may also find application in the determination of the yield of glutamic acid from the hydrolysis of protein materials under different experimental conditions.

Glutamic acid content of some agricultural products and by-products

"Makapuno", matured coconut and copra meal had different amounts of glutamic acid. Copra meal contained almost four times as much as "makapuno" and mature nut possibly because of the higher amount of protein or of nitrogen. However, the protein of "makapuno" seemed to have more glutamic acid than the protein of copra meal and mature nut. The values obtained for the glutamic acid content of the protein were lower than those obtained by other

investigators as compiled by Block and Bolling (1945). The latter investigators, however, determined the acid content of the globulin rather than of the whole coconut protein as was done in this study.

The glutamic acid content of the protein of rice and the different by-products from milling is much lower than those reported in the literature. The proteins of rice bran and of rice polish had the same amount of glutamic acid. Rice hull protein had about as much glutamic acid as the other two.

The two by-products, corn gluten and corn cobs, did not differ very much in the glutamic acid content of their protein, which was very much lower than that reported for corn gluten, one of the raw materials in the manufacture of monosodium glutamate. Corn gluten feed is a by-product of the local starch factory in Cebu which consists of some gluten, hulls, tip caps, and embryo. The nature of the mixture may account for the lower values obtained than the reported values for corn gluten.

Coffee grounds, a possible by-product in the manufacture of soluble coffee, was found to contain 1.22 per cent glutamic acid and its protein had 12.04 per cent acid. On the other hand, coffee husk contained less glutamic acid.

Cacao shell had practically the same amount of glutamic acid on the moisture- and ash-free basis and per 16.0 grams N_2 as coffee grounds. At present, cacao shell is used as an adulterant in cocoa preparation and as animal feed. Cacao husk, a waste product in the processing of the fruits was found to contain a very low amount of glutamic acid (0.7 per cent; 9.10 gm./16 gm. N_2).

Among the legumes, peanut, mongo and ipil-ipil (3.6 to 4.09 per cent), had more glutamic acid than the others. However, the glutamic acid content of their protein, except peanut, did not vary greatly (10.72 to 17.17 per cent) and are within the range reported for other legumes (12.84 to 14.54 per cent). Peanut proteins were found to have 14.24 gms. glutamic acid per 16.0 gm. Na_2 as against 24 per cent as reported by Beiley (1949) and Lilly (1954).

Kapok and lumbang meals had practically the same amount of glutamic acid, but the proteins of lumbang seed meal (18.20 gm. per 16.0 gm. N_2) had more glutamic acid than that of kapok seed (11.03 gm. per 16.0 N_2).

Ramie leaves are among the waste products of the ramie industry. The protein of ramie leaves was found to contain 10.45 per cent glutamic acid which compares favorably with the compiled value for leaf proteins (13.1 per cent).

Abaca sap is a possible by-product in the stripping of the abaca fiber. The sample analyzed had 1.78 per cent total solids which is not too far off from the total solids of Steffen's wastes (2 per cent), one of the industrial raw materials for glutamic acid. The sap was found to contain 6.3 per cent glutamic acid (based on total solids) as compared with the 0 to 15 per cent acid of Steffen's waste (Beiley and Aries, 1949; Lilly, 1954).

RECOMMENDATIONS

On the basis of this study, the proteins of rice bran and rice polish, corn gluten, copra meal and lumbang seed meal, are possible raw materials for glutamic acid production. Although the legumes like mongo, peanut and ipil-ipil have high amounts of glutamic acid, their availability can be a problem. At present, corn gluten is the most logical raw material considering its high glutamic acid content and its availability in the commercial methods of production.

Abaca sap should be thoroughly studied because of its glutamic acid content which is comparable with that of Steffen's waste. In spite of the additional cost of concentrating Steffen's waste from 2.5 per cent to 60-70 per cent total solids, it is still reported to be a practical raw material, especially since it utilizes alkaline hydrolysis, instead of acid hydrolysis, as in the case of the other raw materials. The presence and amount of glutamine have to be established in order that the alkaline hydrolysis may be utilized.

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PARTHENOCARPY AND APOMIXIS IN LANSIUM DOMESTICUM CORREA [1]

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The fruits and seeds of lanzones (*Lansium domesticum* Correa) are autonomously parthenocarpic and apomictic, respectively.

Ants commonly found on the racemes of lanzones seem to have a favorable influence on fruit setting in spite of the absence of pollen grains.

Lanzones (*Lansium domesticum* Correa) trees have been noted to bear both seeded and seedless fruits. It is also known that when fruiting suffers from the effect of inclement weather, the fruits are invariably seedless; whereas, the same tree under normal conditions produces both seeded and seedless fruits in the bunch (Mendiola, 1921).

Cytological studies indicate that lanzones is an octoploid and is highly sterile (Bernardo and Ramirez, 1959). The fact that this fruit tree bears both seeded and seedless fruits in spite of high pollen sterility may indicate the possible occurrence of both parthenocarpy and apomixis. This investigation was conducted in the College Nursery and in the Plant Breeding laboratory from March to September, 1959.

Parthenocarpy refers to the ability of a plant to develop its fruits without actual fertilization, or even without the stimulus that comes from pollination. It has been demonstrated in some plant species which seldom or never develop parthenocarpically that fruits can be made to set by treating the stigmas with certain stimulating agents other than pollen grains. For example, treating receptive stigmas of tobacco with magnesium sulfate and other chemicals have succeeded in setting fruits, and ovaries of certain orchids can be made to develop into fruits by the mechanical irritation of the stigma alone (Gardner, *et al.*, 1939). In their review of parthenocarpy, Gardner, *et al.* (1939) also noted reports on fruits with embryo containing seeds which developed from flower clusters of self-sterile and self-barren apple and cherry varieties when these flowers were at-

[1] Central Experiment Station Contribution No. 2065.

tacked by aphids. Similar fruit setting stimulations caused by gall insects and wasps have been reported.

Apomixis may be defined as the "substitution for sexual reproduction of an asexual reproduction process or one that does not involve fertilization." Its existence in angiosperms has been proven and is now a widely accepted phenomenon by botanists.

The two main types of apomixis are *vegetative apomixis* and *agamospermy*. In vegetative apomixis, vegetative formations such as bulbils in onions are formed instead of seeds. In agamospermy, seed production is affected by asexual means. The gametophyte of the agamospermous species may arise directly or indirectly from a macrospore mother-cell, a process known as *diplospory*. It may also arise from the somatic cells in the nucellus or chalaza, a process known as *apospory*. In any case, megasporogenesis and megagametogenesis often proceed normally. The embryo may develop from an egg-cell without fertilization (a phenomenon spoken of as *parthenogenesis*), or may arise from one of the synergid or antipodal cells (a phenomenon known as *apogamety*). A good review of the different types of apomixis in angiosperms has been made by Stebbins (1941), and a very comprehensive and thorough treatment of its mechanism and cause has been presented by Gustafsson (1946a, 1946b).

The review by Gustafsson (1946a) indicate that in apomictic plants with diplospory and apospory, the polar or fusion nuclei may or may not require fertilization. This has been demonstrated with certainty in many species. In cases where the development of the egg-cell and endosperm takes place quite autonomously, the endosperm may or may not arise before the fusion of the polar nuclei. In such instances, endosperms with either a somatic number or twice the somatic number are possible.

Different hypotheses have been advanced to explain apomixis, but the most logical explanation is that this process is genetically controlled, most likely by a constellation of complementary genes (Stebbins, 1941). Hybridization plays an important role in bringing together these complementary factors and enhancing the production of vigorously sterile or partly sterile types in which apomixis has very high selective value. Polyploidy is usually necessary for the full expression of the genes.

MATERIALS AND METHODS

This study consists of observations on the anthesis of Lanzones and emasculation experiments to test the possible occurrence of parthenocarpy and apomixis in fruit setting and seed development, respectively.

Three trees of the Laguna variety and two of the Mindanao were used. When the experiment was initiated at mid-summer, racemes have already arisen from the branches of both varieties but the flower buds remained dormant because of lack of moisture in the soil. Two Laguna and one Mindanao trees were watered daily for two weeks. This induced early floral development and anthesis.

Flowers on different racemes were tagged and frequent morning and afternoon observations on time and duration of floral opening were made for two weeks. To study the possible occurrence of parthenocarpy and apomixis, 10 to 20 racemes of each tree were selected. The flowers which would open two to five days later were emasculated. Emasculation was done by nipping off each petal below the point of anther attachment. Care was taken not to puncture the stigmas. The rest of the flowers on the racemes were clipped off and the clusters of emasculated flowers were tagged and bagged. DDT (2 per cent solution) was applied around the base of the peduncle of each raceme to prevent the entrance of pollen-carrying insects, especially ants. Unemasculated flowers of about the same age were also bagged to serve as control.

To determine if ants, which are very often teeming around the racemes, have any stimulating influence on fruit setting, 15 racemes for each variety were selected. Flowers that were to expand 2 to 5 days later were emasculated and bagged. Two to three red ants, (*Decophyla smaradina* Fabr.) obtained from non-flowering mango trees were colonized in these bagged racemes.

RESULTS AND DISCUSSION

Sexuality of flowers and anthesis. Merril (1912) describes the flowers of *Lansium* species as small, sub-globose, polygamo-dioecious, the males often panicled, the females in axillary or cauline spikes or racemes. However, he also described the Lanzones flowers as bisexual. Observations made on the Lanzones trees in College revealed neither panicled male flowers nor any polygamo-dioecious condition. All the flowering trees studied had perfect flowers borne in spikes

and were sub-sessile. There were five sepals and five petals which were rounded and imbricate. The stamens were united in a tube and each flower had 10 anthers.

It was difficult to observe the time and duration of anthesis because the thick, imbricate corolla expanded very slowly. Anthesis for the flowers in the inflorescence does not begin simultaneously: some start opening as early as 5 a.m. while others begin to expand as late as 6 p.m.

Flowers between the basal and mid-portion of the raceme usually start to open first, followed by the basal flowers, those at the middle portion of the raceme, and those at the tip. The corolla dehisces about 24 hours after floral opening, but some remain persistent for as long as three weeks or more. Curiously, the petals of Lanzones remain intact, like a crown which rub against the relatively large, butt-like pistil as it is gradually shed off. The persistence of the corolla as referred to here is that it could not be shed off merely because the crown of petals would not easily slide off from the pistil.

Two species of ants were observed to be attacking the racemes: the big red ants (*Decophyla smaradina* Fabr.) and the black ants (*Dolichoderus bituberculatus* Mayr.). The former are much more abundant than the latter.

Fruit setting[2] *after emasculation.* At the early stage of the experiment many whole racemes, emasculated or not, dried up most probably because of the prevailing high temperature during summer. The Mindanao variety appeared to be more sensitive to high temperature than the Laguna variety.

The number of fruits that set in the remaining experimental racemes are summarized in table 1. Counting was done two weeks after emasculation.

Although the data are quite limited, it is interesting to note that considerably high percentages of fruit setting were obtained from both varieties in spite of emasculation and bagging two to five days before anthesis. This strongly indicates autonomic parthenocarpy in Lanzones. Flowers which were emasculated and colonized with red ants gave higher percentages of fruit setting (94.87 per cent for Laguna and 51.43 per cent for Mindanao) than those emas-

[2] Fruit setting refers to the swelling and initial development of the ovary after anthesis.

TABLE 1.—*Percentage of fruit setting in emasculated Lanzones flowers*

VARIETY	TREATMENT	TREE	TOTAL NO. OF RACEMES	TOTAL NO. OF FLOWERS	FRUIT SET	
					Total	Percentage
Laguna	Emasculated, without ants	I	3	14	10	71.43
		II	9	48	42	87.50
		III	18	95	30	31.57
		Total	30	157	82	52.23
	Emasculated, with ants	I	2	12	12	100.00
		II	8	27	25	92.60
		Total	10	39	37	94.87
	Control	I	10	246	133	54.06
		II	10	214	165	77.10
		III	10	278	234	84.17
		Total	30	738	532	72.09
Mindanao	Emasculated, without ants	I	6	51	3	5.88
	Emasculated, with ants	I	5	35	18	51.43
	Control	I	6	145	37	25.51

culated alone (52.23 per cent for Laguna and 5.88 per cent for Mindanao). In fact, their percentages were even higher than those of the control (72.09 per cent for Laguna and 25.51 per cent for Mindanao). However, the fact that comparatively few flowers were emasculated and colonized with red ants does not warrant sufficient confidence to state that the ants have definitely stimulated fruit setting.

The Laguna variety gave considerably higher fruit settings than the Mindanao variety.

Seediness of fruits. Most of the fruits of the Mindanao variety dried up after setting and developing for several weeks, most probably on account of their sensitivity to high temperature. Furthermore, most of the experimental fruits of the Laguna variety were stolen. For these reasons, data on the seediness of only one tree of the Laguna variety were taken (table 2).

TABLE 2.—*Percentage of seedy and seedless Lanzones fruits (Laguna variety) that developed after emasculation*

TREATMENT	NO. OF RACEMES	NO. OF FRUITS	SEEDY FRUITS		SEEDLESS FRUITS	
			Number	Percentage	Number	Percentage
Emasculated, without ants	8	32	8	25.00	24	75.00
Emasculated, with ants	6	10	3	30.00	7	70.00
Control	6	28	5	17.86	23	82.14

The mature fruits varied in size, but size was not correlated with seediness.

Table 2 shows that the percentage of seeded fruits for emasculated flowers without ants (75 per cent) was almost as high as that for the control (82.14 per cent). This explains why seed development in Lanzones is independent of both fertilization and stimulation as caused by pollination. The percentage of seeded fruits (70) obtained from emasculated flowers in which ants were colonized was considerably lower than the percentage of seeded fruits obtained from flowers that were emasculated alone.

Some of the seeded fruits were single-seeded while others were two or three-seeded. The seeds varied in size. The two or three-seeded fruits mostly had only one big seed (about 1 cm. or more in width) and one medium-sized seed (about 0.5 cm. to 1 cm.) and/or one small seed (less than 0.5 cm.). Each fruit segment without any seed bore a thick, brownish core which is most probably composed of the seed coat and the aborted embryo. Embryo abortion may be caused by genetic factors. For instance, the ovaries of date palm and coconut palm each contain three ovules, two abort, leaving only one to develop (Gardner, *et al.*, 1939). The same phenomenon has been noted in many fruit trees.

The absence of seeds in some fruits may also be due to embryo abortion.

Viability of the seeds. The seeds of the fruits which developed from the control and the emasculated flowers were germinated. Most of the seeds were damaged by earthworms and only a few germinated. Six seedlings were obtained from the control and two from the emasculated group.

SUMMARY AND CONCLUSION

1. The results of emasculation experiments in Lanzones indicate that the fruits and seeds of this fruit tree are autonomously parthenocarpic and apomictic, respectively. This finding on the development of Lanzones seeds without fertilization or stimulation as caused by pollination indicates that the possibility of breeding for seedless varieties is nil.

2. Considerably more fruit setting but less seediness was obtained from fruits that were emasculated and colonized with red ants as compared with those that were emasculated alone, and those of the control.

3. Embryological investigations should be conducted to determine the type and nature of apomixis in this fruit tree.

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A STUDY ON THE QUANTITY AND CHEMICAL COMPOSITION OF THE COLOSTRUM OF EWES [1]

AUGUSTO E. FELIX, VALENTE VILLEGAS, EPIFANIA C. CRUZ, and L. L. CLAMOHOY

The milk of ewes was considered as colostrum seven days after lambing as indicated by differences in percentage amounts of majority of the constituents like moisture, protein, fat, and lactose from those of normal milk. The total average production of colostrum throughout was 761.94 ml. The minimum yield amounted to an average of 28.32 ml. which occurred on the first day. The maximum yield was on the third day with an average of 150.32 ml. The moisture content of colostrum was 76.27 ± 0.48 per cent; protein, 7.51 ± 0.50 per cent; fat, 8.46 ± 0.53 per cent; lactose, 7.32 ± 0.84 per cent; and ash, 0.87 ± 0.02 per cent.

Colostrum is the milk yielded by the mother for a short time after giving birth. It differs greatly in composition from ordinary milk (Morrison, 1948). It is indispensable in the life of suckling animals who are apt to die in its absence. Colostrum received by a calf the first day has as much vitamin A as it would secure from ordinary milk.

Villegas (1954) stated that colostrum is rich in vitamin A, is very high in globulin, and has a laxative effect which aids in cleansing the digestive tract of accumulated fecal matter present at birth. Colostrum contains antibodies which are valuable in fighting common diseases of the new born.

Villegas (1957) [2] found later that the chemical analysis of normal milk of ewes is: moisture, 80.79 ± 0.99 per cent; protein, 4.70 ± 0.17 per cent; fat, 7.77 ± 0.27 per cent; lactose, 5.95 ± 0.14 per cent; ash, 0.92 ± 0.02 per cent; and specific gravity, 1.035 ± 0.10.

Maynard and Loosli (1956), citing Braude *et al.*, enumerated the constituents of sheep's milk, as follows: moisture, 80.1 per cent; protein, 5.8 per cent; fat, 8.2 per cent; lactose, 4.8 per cent; and ash, 0.92 per cent. Espe and Smith (1952) said that the composi-

[1] Central Experiment Station Contribution No. 2066. Research Project No. 2511.

[2] V. E. Villegas, "Ewes for Dairy Purposes," 1957. Unpublished.

tion of milk of sheep is as follows: moisture, 82.9 per cent; protein, 5.4 per cent; fat, 6.2 per cent; lactose, 4.3 per cent; and ash, 0.9 per cent. Coffey (1947) cited the percentages of the constituents of ewe's milk as follows: moisture, 80.8 per cent; protein, 6.5 per cent; fat, 6.9 per cent; lactose, 4.9 per cent; and ash, 0.9 per cent.

To determine the quantity and chemical composition of colostrum of ewes, this investigation was conducted in the Department of Animal Husbandry from June, 1956 to June, 1957.

MATERIALS AND METHODS

Twenty-two healthy ewes of a strain of sheep developed at the College of Agriculture were used. The average age was four years, five months and twelve days, the range being from one year, six months and nine days to seven years, nine months and twenty-three days.

Ewes in the flock were observed, more attention being given to those that were in advanced pregnancy. Soon after delivery, the lamb of each ewe was immediately separated from its dam, not allowing it to nurse. The dam was confined to a pen where she was milked as fully as possible twice daily (morning and afternoon), until the tenth day after pasturition. In the pen, she was given soilage twice a day and concentrate mixture once a day. Salt and water were also supplied.

The total collection at each milking was measured and sampled carefully. Samples of the milk were collected from each milking for the determination of the specific gravity, moisture, protein, fat, lactose, and ash. If the samples could not be analyzed immediately, they were stored in the refrigerator.

RESULTS AND DISCUSSION

Yield of milk. Table 1 shows the daily yield of milk. The average volume of milk collected on the first day was 28.32 ml., the range being from 3 to 134 ml. The yield on the second day was much higher, an average of 128.68 ml., the variation being 13 to 335 ml. The highest production was on the third day with an average of 150.32 ml., the variation being from 28 to 405 ml. On the fourth day, the average yield was 145.43 ml., the range being from 16 to 367 ml. The average yield decreased gradually from the fourth to the tenth day.

TABLE 1.—*Daily milk yield for ten days after lambing*

DAYS	NUMBER OF SAMPLES	AVERAGE YIELD	RANGE IN YIELD
		ml.	*ml.*
First	22	28.32	3.0 to 134.0
Second	22	128.68	13.0 to 335.0
Third	22	150.32	28.0 to 405.0
Fourth	22	145.43	16.0 to 367.0
Fifth	22	116.07	9.0 to 306.0
Sixth	22	99.42	3.0 to 254.0
Seventh	21	93.70	3.0 to 238.0
Eighth	18	91.42	9.5 to 242.5
Ninth	18	73.42	8.5 to 201.0
Tenth	17	74.88	7.0 to 221.0
Mean		100.63 ± 6.22	

One ewe went dry on the seventh day, three ewes on the eighth day, and one ewe on the tenth day.

Specific gravity. The specific gravity of the milk is found in table 2. Its highest specific gravity was on the first day, with an average of 1.046. Normal specific gravity appeared on the fourth day although it tended to go down during the remaining periods.

TABLE 2.—*Average specific gravity and chemical analysis of the milk of ewes*

DAYS	NUMBER OF ANIMALS	SPECIFIC GRAVITY	MOISTURE	PROTEIN	FAT	LACTOSE	ASH
			Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
First	22	1.046	74.26	11.56	6.96	8.15	0.85
Second	22	1.042	77.25	8.34	6.78	7.02	0.92
Third	22	1.042	75.09	5.76	8.43	8.47	0.93
Fourth	22	1.036	77.11	6.41	10.21	10.94	0.90
Fifth	22	1.031	75.60	5.77	10.31	7.18	0.85
Sixth	22	1.030	77.23	8.08	8.35	5.52	0.78
Seventh	21	1.031	77.35	6.67	8.21	3.94	0.83
Eighth	18	1.030	80.63	4.48	7.27	6.24	0.85
Ninth	18	1.033	81.17	3.59	7.50	6.84	0.84
Tenth	17	1.032	83.22	4.46	6.44	5.43	0.78
Chemical analysis of normal milk [a]		1.035	80.79	4.70	7.77	5.95	0.92

[a] V. E. Villegas, "Ewes for dairy purposes," 1957 (Unpublished).

Moisture. Table 2 indicates the moisture content of the milk. On the first day, the average moisture content was 74.26 per cent; on the second day, 77.25 per cent; on the third day, 75.09 per cent; on the fourth day, 77.11 per cent; on the fifth day, 75.60 per cent; on the sixth day, 77.23 per cent; on the seventh day, 77.35 per cent; on the eighth day, 80.63 per cent; on the ninth day, 81.17 per cent; and on the tenth day, 83.22 per cent. The average moisture contents from the first to the seventh day were almost the same and appeared lower than those obtained later.

Protein. The average percentages of protein are shown in table 2. The highest content was on the first day (11.56 per cent), while the lowest was on the ninth day (3.59 per cent). The average percentage of protein was variable. It showed higher protein content on the first day of lactation with a tendency to go down until the tenth day. On the eighth day, protein content appeared normal.

Fat. Average fat figures are in table 2. The average fat percentage increased from the first day with 6.96 per cent to the fifth day with its maximum percentage of 10.31. From the sixth until the tenth day, the fat content gradually decreased. Normal fat content was obtained on the eighth day.

Lactose. The average percentages of lactose are shown in table 2. The highest percentage was 10.94 on the fourth day and lowest on the seventh day with 3.94 per cent. Normal lactose content was evident on the eighth day of lactation.

Ash. The average ash percentage amounts are found in table 2. The content of ash on the first day was 0.85 per cent; on the second and third days, 0.92 and 0.93 per cent, respectively; on the fourth day, 0.9 per cent; on the fifth day, 0.85 per cent; on the sixth day, 0.78 per cent; on the seventh day, 0.83 per cent; on the eighth day, 0.85 per cent; on the ninth day, 0.84 per cent; and on the tenth day, 0.78 per cent. The highest percentage (0.93) was on the third day. The lowest percentage was on the sixth and tenth days, with 0.78 per cent.

It is evident that based on previous findings of other earlier mentioned workers, ash and moisture content appeared normal on the second and eighth days, respectively. Foreign findings on the appearance of normal protein, fat and lactose varied greatly and seemed to appear much earlier than the eighth day. However, the

local data presented by Villegas (1957)[3] showed that these three chemical constituents occurred consistently on the eighth day of lactation.

Yield of colostrum. Table 3 shows the daily yield of colostrum. The average minimum yield of colostrum was 28.32 ml. on the first day. The yield on the second day increased to an average of 128.68 ml. The highest production was on the third day with an average yield of 150.32 ml. The yield decreased progressively to the seventh or last day. The total production of colostrum throughout was 761.94 ml., the mean being 107.28 ± 7.78 ml.

TABLE 3.—*Daily yield of colostrum*

DAYS	AVERAGE YIELD	RANGE IN YIELD
	ml.	*ml.*
First	28.32	3.0 to 134.0
Second	128.68	13.0 to 335.0
Third	150.32	28.0 to 405.0
Fourth	145.43	16.0 to 367.0
Fifth	116.07	9.0 to 306.0
Sixth	99.42	3.0 to 254.0
Seventh	93.70	3.0 to 238.0
Mean	107.28 ± 7.78	

Constituents of colostrum. Table 4 shows the average percentages of constituents in the colostrum. The mean moisture content

TABLE 4.—*Average specific gravity and chemical composition of colostrum*

DAYS	SPECIFIC GRAVITY	MOISTURE	PROTEIN	FAT	LACTOSE	ASH
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
First	1.046	74.26	11.56	6.96	8.15	0.85
Second	1.042	77.25	8.34	6.78	7.02	0.92
Third	1.042	75.09	5.76	8.43	8.47	0.93
Fourth	1.036	77.11	6.41	10.21	10.94	0.90
Fifth	1.031	75.60	5.77	10.31	7.18	0.85
Sixth	1.030	77.23	8.08	8.35	5.52	0.78
Seventh	1.031	77.35	6.67	8.21	3.94	0.83
Mean	1.037 ± 0.002	76.27 ± 0.48	7.51 ± 0.50	8.46 ± 0.53	7.32 ± 0.84	0.87 ± 0.02

[3] *Ibid.*

of colostrum was 76.27 ± 0.48 per cent; mean protein content, 7.51 ± 0.50 per cent; mean fat content, 8.46 ± 0.53 per cent; mean lactose content, 7.32 ± 0.84 per cent; and the mean ash content, 0.87 ± 0.02 per cent. The mean specific gravity of colostrum was 1.037 ± 0.002.

Lactation period. Of the twenty-two ewes, two had their first lactation; one, its second; three, their third; four, their fourth; none had its fifth; one, its sixth; six, their seventh; four, their eighth; and the rest had none except one which had its thirteenth lactation period.

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ERRATA

In volume XLIV, No. 1, June, 1960 number of *The Philippine Agriculturist*, page 54, table 4, subheads 40^{2} and 20^{1} should be transposed, and the data for Milfor 6 on column 3 should be deleted.

In volume XLIV, No. 7, December, 1960 number of *The Philippine Agriculturist*, page 338, line 2 (abstract), the word "resistance" hould be deleted.

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